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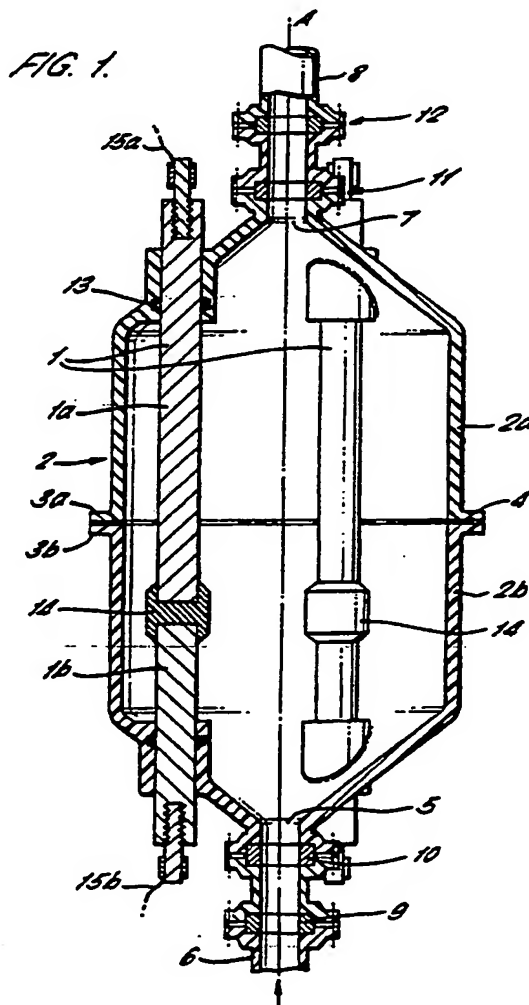
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GB 2229900 A GB 1095385 A GB 0725568 A

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(54) Internal resistance ohmic heating apparatus for fluids

(57) Ohmic heating apparatus for heating electrically conductive fluid comprises electrodes (1) to be immersed in the fluid to be heated which are connected to a three phase power supply. The electrodes comprise a number of electrically separate electrode elements (1a, 1b). The electrical power supply includes switch means for switching electrical power to selected electrode elements (1a, 1b) to adjust the effective electrode surface area. Guard rings (10, 11) (9, 12) are connected to neutral and earth respectively to reduce and measure leakage current. The switch means responds to the magnitude of the current in the supply line.



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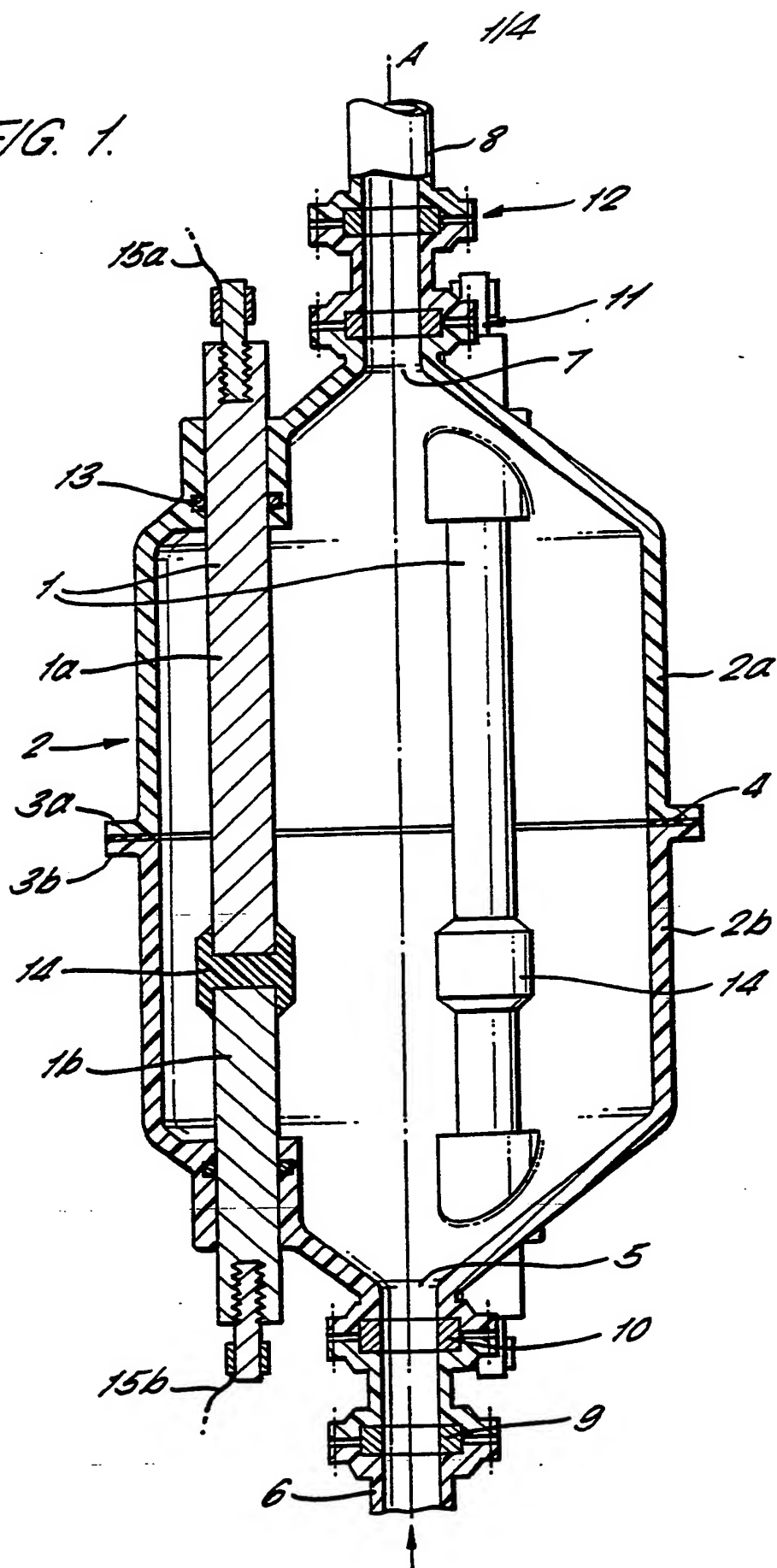


FIG. 2.

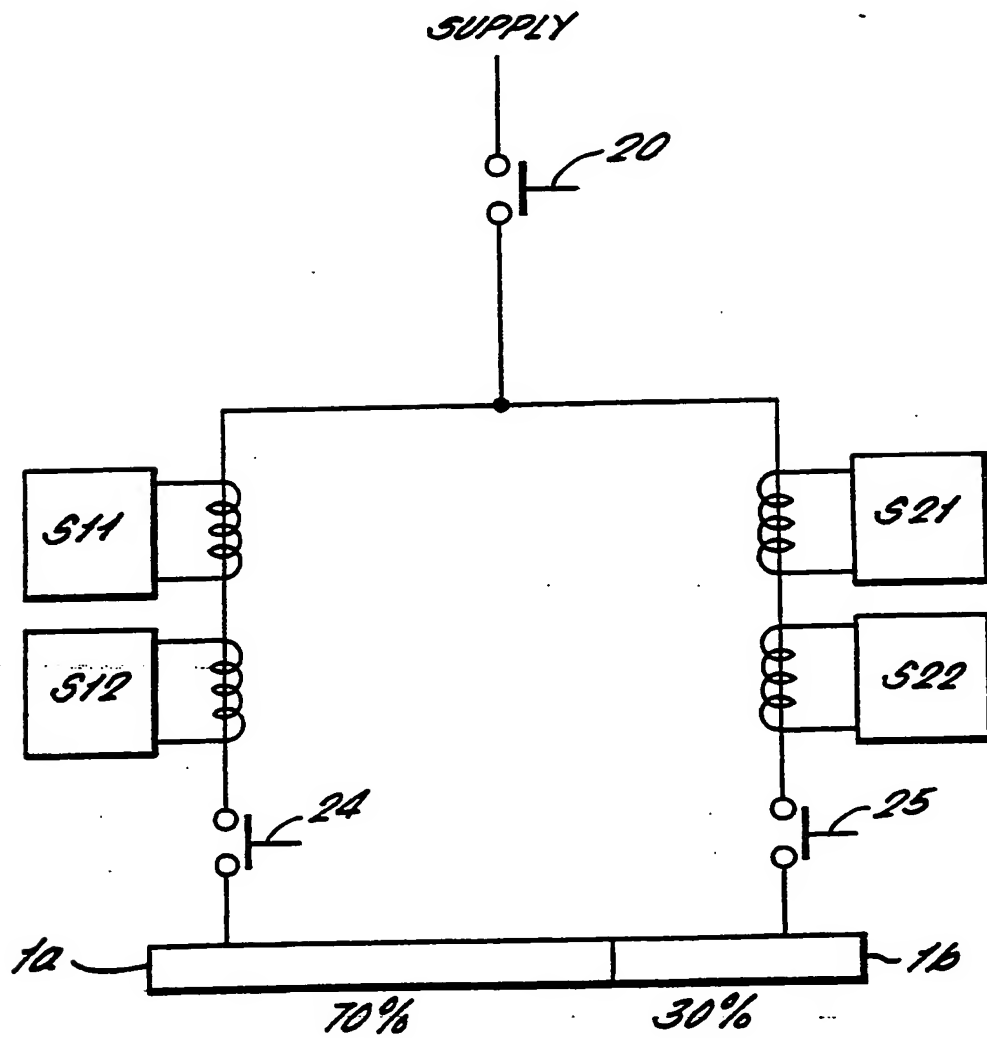
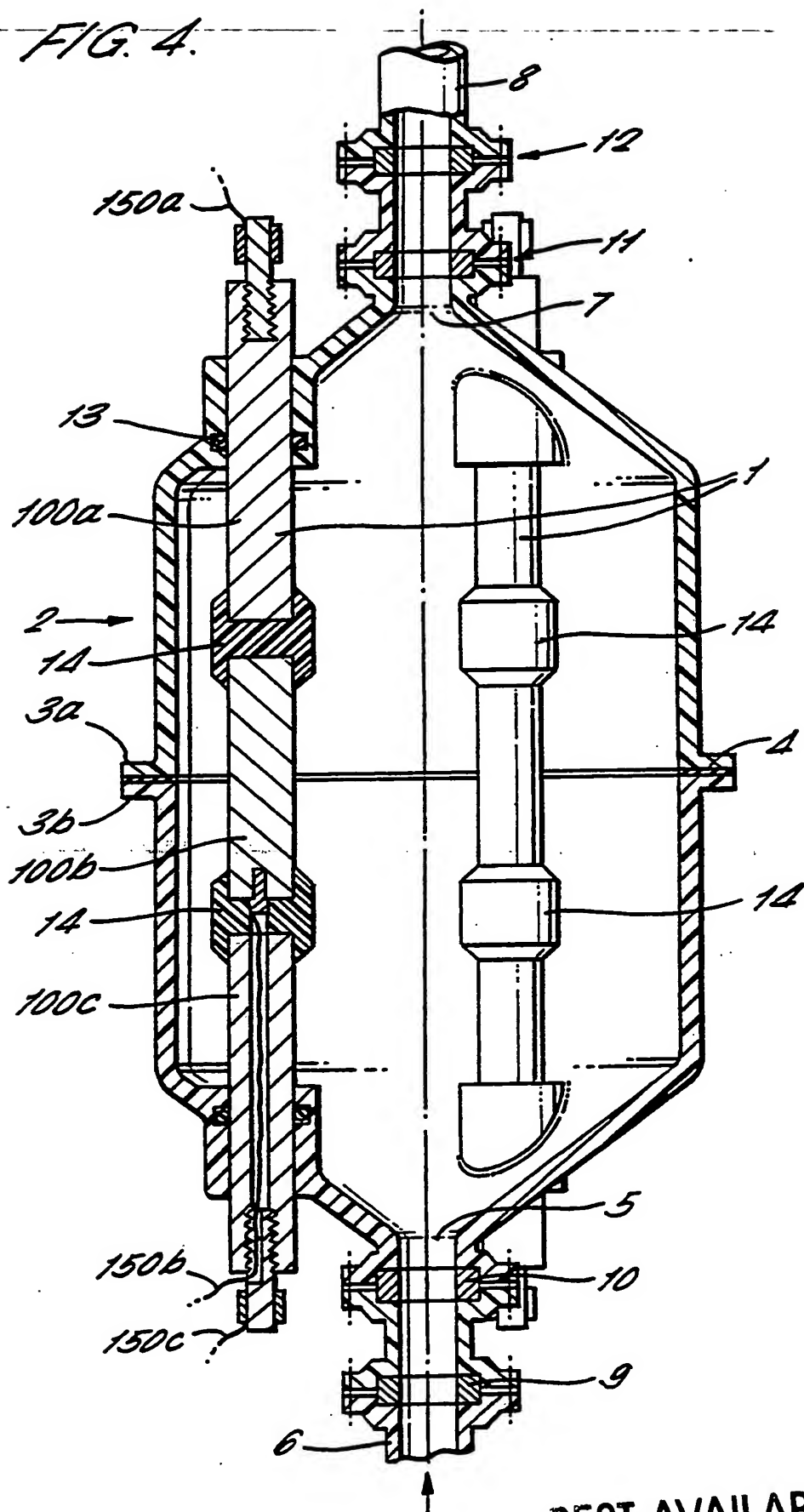




FIG. 4.



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OHMIC HEATING APPARATUS

The present invention relates to ohmic heating apparatus, which heats a fluid by passing an electric current through the fluid. This type of heater is used for fluids which require heating but which might foul or block conventional heaters.

Arrangements are known where the current is passed longitudinally or in the direction of flow of the fluid. However, in these systems, due to the uneven flow of the fluid in the container, there is uneven heating in the fluid.

Also known are transverse ohmic heaters in which the current is passed between electrodes transversely, or perpendicular to the flow of the fluid. However, in such arrangements some of the current may flow to earthed components in the apparatus such as the ends of the connecting pipes to and from the heater. This is termed a leakage current, and can give rise to an acceptably high level of electrolytic corrosion or fouling of the pipe ends which foul these currents.

An ohmic heater disclosed in GB 2243064 overcomes these problems by providing a vessel having inlet and outlet ports between which the fluid flows when in use along an axis. At least two electrodes (3 for a three-phase power supply) are arranged to be spaced about the axis flow and are contained within the vessel. Electric power is applied to the electrodes such that electric potential at any time on the axis is substantially zero relative to earth. This arrangement has the advantage

that the fluid along the axis of flow is maintained at or near earth potential, so that current leakage to pipe ends is significantly reduced.

However, operation of this type of transverse ohmic heater has shown that one difficulty which is encountered in operational use is the variation in the current drawn by the heater and hence in the magnitude of the heating effect, due to changes in the electrical conductivity of the fluid which is being heated. A particular example of this is where an ohmic heater is being used to raise the temperature of untreated sewage, as a part of a modified treatment process. There is no way in which the electrical conductivity of sewage can be controlled or modified by adjusting the process conditions. It is entirely dependent on the make-up of the effluent. This can vary considerably over very short time spans. For instance, a period of frosty weather, during which Local Authorities spread grit and salt on the road surfaces, followed by rain which washes the salt solution into the sewers can lead to a four-fold rise in the electrical conductivity of the sewage in a matter of a few hours.

Conductivity variations of this magnitude can only be allowed for in the ohmic heater disclosed in GB 2243064 by over designing the heater so that it has the capacity to cope with the highest conductivity levels likely to be encountered in operation. In the case of sewage this would entail a heater and installed electrical supply capacity some four times greater than is used during normal operation of the heater: some 90% of the time. This is clearly a considerable expense.

The object of the present invention is therefore to provide a ohmic heating apparatus which can cope with large variations in the electrical conductivity of the fluid to be heated, without having to oversize the heater or install

gross electrical supply overcapacity.

The present invention provides ohmic heating apparatus for heating electrically conductive fluid, said apparatus comprising electrode means to be immersed in the fluid to be heated, and supply means to supply electric power to the electrode means, wherein the electrode means comprise a plurality of electrically separate electrode elements, and said supply means includes switch means for switching electric power to selected said electrode elements to adjust the effective electrode surface area.

In one embodiment of the present invention the ohmic heating apparatus includes a vessel having inlet and outlet ports between which said fluid flows when in use, along a longitudinal axis; said electrode elements being arranged to be spaced within said vessel about said axis; said supply means being operative to supply electric power to said electrode elements such that the electric potential at any time on said axis is one of a) substantially zero relative to earth, and b) the neutral potential of the electric power supply.

Preferably the conductivity of the fluid is monitored by the use of current detection means which detects the current flow in the fluid from the electrode members. The switch means is operative in response to said detection means to switch electric power to selected said electrode elements to increase the effective electrode surface area in response to a decrease in detected current, and to decrease the effective electrode surface area in response to an increase in detected current.

Preferably said electrode elements are elongate and extend along the direction of flow of said fluid.



In one embodiment the electrode elements are arranged as a plurality of sets of electrode elements, a set of electrode elements comprising a plurality of electrode elements having the same longitudinal position.

In one embodiment the switch means is operative to switch electric power to more or less sets of electrode elements.

The electrode elements can be of the same length.

In one preferred embodiment the ohmic heating apparatus comprises a first and second set of electrode elements, electrode elements of said first set of electrode elements have a length of about twice the length of electrode elements of said second set of electrode elements.

In such an embodiment the switch means is preferably operative to switch electric power to both said first and second sets of electrode elements, said second set of electrode elements, or said first set of electrode elements in response to a predetermined detected current, a two-fold increase or a three-fold increase in the detected current respectively.

In one embodiment the supply means includes a threshold switch to switch off the supply of electric power to said electrode elements when the current exceeds a predetermined threshold, said threshold switch being operative to switch on the supply of electric power after a predetermined time delay.

Preferably the electrode elements extend parallel to the axis and conveniently each set of electrode elements comprises three electrode elements which are each connected to a single phase of a three-phase electric power supply.

In order to reduce leakage currents, preferably the inlet and outlet ports are positioned at opposite ends of the vessel on said axis, said ports being substantially smaller in area than the cross-sectional area of said

vessel.

To further reduce leakage currents, preferably an electrically conductive guard ring is positioned to lie around the periphery of each the ports and means to connect the guard ring to earth are provided.

In order to provide a measure of the earth leakage current, preferably a second electrically conductive guard ring is positioned to lie around the periphery of each of the ports at a position nearer to the electrode elements than the first guard ring. This second guard ring is connected to the neutral of the electric power supply.

The present invention also provides a method of ohmically heating an electrically conductive fluid comprising the steps of immersing electrode means in the fluid to be heated and supplying electric power to selected electrode elements of a plurality of electrically separate electrode elements to adjust the effective electrode surface area.

Examples of the present invention will now be described with reference to the accompanying drawings, in which:-

Figure 1 is a longitudinal sectional view of an ohmic heating apparatus according to one embodiment of the present invention;

Figure 2 is a schematic illustration of an electrical control circuit for the ohmic heating apparatus of Figure 1;

Figure 3 illustrates one detailed form of the circuitry to carry out the switching sequence;

Figure 4 is a longitudinal sectional view of an ohmic heater according to a second embodiment of the present invention.

Referring now to Figure 1, this drawing illustrates one embodiment of the ohmic heating apparatus wherein

electrode elements are arranged to be parallel to the axis of the flow of fluid to be heated.

The vessel 2 comprises two identical halves, an upper half 2a and a lower half 2b. These two halves are connected together by respective flanges 3a and 3b. The flanges are retained by bolts. A seal 4 is provided between the flanges 3a and 3b in order that the upper and lower halves 2a and 2b form the watertight vessel 2.

The vessel 2 is constructed from a suitable electrically insulating material and has a wall thickness that is adequate to withstand the internal pressures applied or generated in the heater: for example by any tendency for the heated fluid to boil.

In the centre of the bottom of the lower half 2b of the vessel 2 is an inlet port 5. The internal face of the lower half 2b tapers from the internal diameter of a cylindrical part of the lower body to the diameter of the inlet port 5. The inlet port 5 is arranged to form a connection with an inlet pipe 6.

Similarly, the upper half 2a of the vessel 2 has a cylindrical portion and a portion tapering to one end to an outlet port 7. The outlet port 7 is arranged to form a connection with an outlet pipe 8.

At both the inlet and outlet ports 5 and 7, there are provided two electrically conductive guard rings 9, 10, 11 and 12. In the inlet and outlet ports 5 and 7 the electrically conductive guard rings 10 and 11 nearest the interior of the vessel 2 are connected to the neutral point of a three-phase electrical power supply. The electrically conductive guard rings 9 and 12 furthestmost from the interior of the vessel 2 are connected to earth. The electrically conductive guard rings 9, 10, 11 and 12 not only reduce the leakage current from the vessel 2 but also enable a measure to be made of the leakage current.

At regular spacings around the upper end of the upper half 2a and the lower end of the lower end 2b of the vessel, three rod shaped electrodes 1 project through the wall and into the vessel 2. The electrodes 1 are sealed with the wall of the upper and lower halves 2a and 2b of the vessel 2 by O-ring seals 13. This prevents the loss of fluid from the interior of the vessel 2. The electrodes 1 extend parallel to the axis of the vessel 2 and are segmented to form two electrode elements 1a and 1b. The two electrode elements 1a and 1b are separated by an insulating spacer 14. One electrode element 1b is 30% of the total length of the electrode 1, and the other electrode element comprises the remaining 70%. Each electrode element 1a and 1b is connected at their distal ends outside the interior of the vessel to respective power supplies by respective connections 15a and 15b. When in use, each electrode 1 is electrically connected by the wires 15a and 15b to a single phase of a three-phase power supply (not shown). The electrodes 1 are equally spaced around the axis A of the flow of fluid and they lie at the apices of an equilateral triangle, wherein the centroid of the equilateral triangle falls at the axis A of the vessel 2 which is also the axis of the flow of fluid to be heated.

The two electrode elements 1a and 1b of each electrode 1, although taking power from the same phase of the three-phase power supply, are individually controlled as will be seen hereinafter.

When in operation, a fluid to be heated is passed into the input pipe 6 and flows through the vessel 2 to the output pipe 8. The direction of flow of the fluid is indicated in the drawing by the arrow. Whilst the fluid is passing the electrodes 1, either one or both of the electrode elements 1a and 1b of the electrodes 1 are energised by connection to a single phase of a three-phase

power supply (not shown).

Thus, apart from the segmentation of the electrodes 1, the structure and operation of the ohmic heating apparatus is similar to that disclosed in GB 2243064, the contents of which is hereby incorporated by reference.

As discussed in GB 2243064, the arrangement of the electrodes about the axis provides balanced phase currents for the three-phase power supply and the axis will always be maintained at or very near the common electrically neutral voltage level of a three-phase voltage applied to the electrodes, as long as a current balance is maintained between them.

Thus, with the inlet and outlet ports 5 and 7 being arranged on axis and being provided with electrically conductive guard rings 9, 10, 11 and 12, an extremely safe arrangement is provided with minimal leakage currents.

The provision of electrodes 1 having two elements 1a and 1b allows for a three-fold increase in conductivity to be catered for. In operation, either or both of the electrode elements 1a and 1b of each electrode 1 can be connected to the three-phase supply. When only one of the electrode elements 1a or 1b is energised the other is allowed to electrically float in order to avoid currents flowing between electrode elements of the same electrode. Electrode elements 1a and 1b of different electrodes 1 that lie in similar longitudinal positions form what can be termed a set and are energised together by connection to the three-phase supply. Thus the respective electrode elements 1a, 1b at the same longitudinal position in each electrode 1 are always energised simultaneously, so as to maintain phase balance. The control of the supply of current to the electrode elements 1a and 1b allows for the net current drawn by the ohmic heating apparatus to be limited to about 40%, 70% or 100% of that drawn by an ohmic

heater having full length electrodes. This can be performed by a simple switching procedure as will be seen hereinafter. Thus the maximum current carrying capacity of the ohmic heating apparatus can be limited by reducing the active length of the electrodes.

Figure 2 illustrates the general form of electrical control circuit to control the current supply to the electrodes 1 in the ohmic heating apparatus of Figure 1. This drawing illustrates a single phase of the three-phase supply. A single phase of a three-phase supply is provided to each electrode elements 1a and 1b via a main contactor 20 and element contactors 24 and 25 for electrode elements 1a and 1b respectively. The power supply line for the electrode element 1a which is 70% of the length of the electrode 1, is provided with two current sensors S11 and S12. S11 detects when the current in the supply line to the electrode signal 1a reaches 100% of the power supply rating. The second current sensor S12 detects when the current reaches 70% of the power supply rating.

The power supply line for the second electrode element 1b is similarly provided with two current detectors S21 and S22. The first current detector S21 detects when the current reaches 100% of the power supply rating. The second current detector S22 detects when the current reaches 40% of the power supply rating. Although the electrode elements 1b are 30% of the length of the electrode 1, when the electrode elements 1b are switched on they will draw  $70/30 \times 100\%$ , i.e. 42% of the rated heater current, if the electrode elements 1a have been drawing 70% of the rated heater current.

Figure 3 illustrates the detailed circuitry which carries out the switching of the contactors 20, 24 and 25 using signals from the four current detectors S11, S12, S21 and S22.

In Figure 3 the four current detectors S11, S12, S21 and S22 are shown to operate four respective switches. These operate at the preset current levels of 100%, 70% and 40% as detected. The contactors 20, 24 and 25 are operated when the relays RL20, RL24 and RL25 are energised. The contactors 20, 24 and 25 may be any suitably operated three-phase contactors for a particular ohmic heater capacity. For simplicity, the whole circuit operates at the phase voltage (conveniently 240V) of the main supply although any other a.c. or d.c. voltage devices may be employed.

The circuit in Figure 3 is provided with a common neutral and a live connection. The mode of operation of the circuit will now be described.

When the circuit is switched on from cold, all the switches S11, S12, S21 and S22 are in the 'normal' position and all the switches controlled by the changeover relays RL1, RL2 and RL3 are closed. When the power supply is turned on, current flows via switch S11, S12 and relay switch RL2/b to relay RL25 to close the contactor 25. Also current flows via relay switch RL2/a and relay switch RL1/b to relay RL24 to close contactor 24. Thus the ohmic heater is fully energised in that both electrode elements 1a and 1b of the electrode is connected to the power supply.

If the current in electrode segment 1a rises to 70% of the rated maximum heater current, switch S12 opens since the set point of switch S12 is preset at 70%. The electrical feed to the relay RL25 via switch S12 and relay switch RL2/b is cut. The connection to the relay RL25 via relay switch RL1/b and relay switch RL2/c is not available since relay RL1 is still in 'normal' position. The electrode element 1b is thus disconnected from the power supply. The current in electrode element 1a remains at or above 70% however.

If the current in electrode element 1a now drops below 70%, switch S12 recloses (the 'hysteresis' is set to a minimum value) and electrode element 1b is re-energised via switch S11, S12 and relay switch RL2/b, which is still in the 'normal' position.

If the heater current (current in electrode element 1a) rises above 100% of the rated maximum heater current, switch S11 reverses (switch S12 still being open) so that switch S12 and relay RL2 cannot become energised. Relay RL1 is energised, thus closing contactor 2 via relay switch RL1/b (relay switch RL2/a and relay switch RL2/c are still 'normal') and contactor 24 is opened via relay switch RL1/b. Thus electrode element 1b is energised and immediately starts to draw over 40% of the maximum rated heater current. Switch S22 is set to switch over at 40% and does so and latches relay RL1 on via relay switch RL1/a. This holds the electrode element 1a off and the electrode element 1b on as long as switch 22 detects more than 40% current flow from electrode element 1b. The current in electrode element 1a drops to zero, so switch S11 and switch S12 both revert to 'normal'.

If the heater current (current electrode element 1b) now drops below 40%, switch S22 opens, unlatching relay RL1, which thus reverts to 'normal'. This in turn energises relay RL24 (and thus electrode element 1a) and de-energises relay RL25 (electrode element 1b). The situation is now as that for 70% current, i.e. only electrode element 1a is connected to the power supply.

If the heater current (current in electrode element 1b) rises to 100%, switch S21 opens, energising relay RL2 (switch S11 and switch S12 are both 'normal', i.e. closed since electrode element 1a is off). Relay RL2 latches on (via relay switch RL1/a) and de-energises relay RL25 via relay switch RL1/c (and relay switch RL1/b). Relay RL24 is



held off via relay switch RL1/a. Relay RL23 is energised and after a preset time (20 minutes or so) opens switch S1. This de-energises the whole circuit, resetting relay RL1 and relay RL2 to 'normal' and leaves the contactors 24 and 25 off. Both electrode elements 1a and 1b are thus held off for the preset time delay.

When relay RL3 re-opens the switch S1 after the time delay, the system is as at the start of operation of the heater as from cold.

Thus the circuit arrangements shown in Figures 2 and 3 are able to control the energising of electrode elements 1a and 1b such that effective length of the electrodes 1 can be varied from 40% to 70% to 100%. This is controlled by the current detected flowing from the electrode elements 1a and 1b through the fluid within the vessel 2.

Figure 4 illustrates an alternative embodiment of the present invention wherein each electrode 1 is segmented into a number of equal length electrode elements 100a, 100b, 100c. Each electrode element 100a, 100b and 100c are connected to a power supply by respective connections 150a, 150b and 150c. To enable connection to electrode element 100b, electrode element 100c is hollow to allow the connection to be made. Electrode elements of corresponding longitudinal position in different electrodes 1 can be energised as a 'set'. The number of sets of electrode elements energised can be controlled in order to vary the length of the electrode which is supplied with electric power. Although only three electrode elements are shown in Figure 4, any number of electrode elements can be used, thus providing a wide range of control for heating fluids with wide electrical conductivity variations. In order to control the energisation of this arrangement a Programmable Logic Controller (PLC) is used, as is widely commercially available.

Although the embodiments hereinabove have been described having elongate electrodes segmented along their length, and energised using a three-phase a.c. supply, the present invention is applicable to any electrode arrangement wherein the surface area of the electrode that is energised, either by an a.c. or d.c. voltage, can be varied for instance in dependence upon the conductivity of the fluid being heated.

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CLAIMS

1. Ohmic heating apparatus for heating electrically conductive fluid, said apparatus comprising electrode means to be immersed in the fluid to be heated, and supply means to supply electric power to the electrode means, wherein the electrode means comprises a plurality of electrically separate electrode elements, and said supply means includes switch means for switching electric power to selected said electrode elements to adjust the effective electrode surface area.
2. Ohmic heating apparatus as claimed in Claim 1 including a vessel having inlet and outlet ports between which said fluid flows when in use, along a longitudinal axis; said electrode elements being arranged to be spaced within said vessel about said axis; said supply means being operative to supply electric power to said electrode elements such that the electric potential at any time on said axis is one of a) substantially zero relative to earth, and b) the neutral potential of the electric power supply.
3. Ohmic heating apparatus as claimed in Claim 1 or Claim 2 including current detection means to detect current flowing in said fluid; wherein said switch means is operative in response to said detection means to switch electric power to selected said electrode elements to increase the effective electrode surface area in response to a decrease in detected current, and to decrease the effective electrode surface area in response to an increase in detected current.

4. Ohmic heating apparatus as claimed in any preceding claim, wherein said electrode elements are elongate and extend longitudinally along the direction of flow of said fluid.

5. Ohmic heating apparatus as claimed in Claim 4, wherein said electrode elements are arranged as a plurality of sets of electrode elements, a set of electrode elements comprising a plurality of electrode elements having the same longitudinal position.

6. Ohmic heating apparatus as claimed in Claim 5, wherein each set of electrode elements has an equal plurality of electrode elements which are arranged in the same radial positions spaced about said axis.

7. Ohmic heating apparatus as claimed in Claim 5 or Claim 6,, wherein said switch means is operative to switch electric power to more or less sets of electrode element.

8. Ohmic heating apparatus as claimed in any preceding claim, wherein said electrode elements are of the same length.

9. Ohmic heating apparatus as claimed in Claim 5, comprising a first and second set of electrode elements, electrode elements of said first set of electrode elements have a length of about twice the length of electrode elements of said second set of electrode elements.

10. Ohmic heating apparatus as claimed in Claim 9, wherein said switch means is operative to switch electric power to both said first and second sets of electrode elements, said second set of electrode elements, or said

first set of electrode elements in response to a predetermined detected current, a two-fold increase or a three-fold increase in the detected current respectively.

11. Ohmic heating apparatus as claimed in Claim 10, wherein said supply means includes a threshold switch to switch off the supply of electric power to said electrode elements when the current exceeds a predetermined threshold, said threshold switch being operative to switch on the supply of electric power after a predetermined time delay.

12. Ohmic heating apparatus as claimed in any of Claims 4 to 11, wherein said electrode members extend parallel to said axis.

13. Ohmic heating apparatus as claimed in Claim 6, wherein each set of electrode elements comprise three said electrode elements, and said supply means is operative to connect each said electrode element having the same radial position spaced about said axis to a single phase of a three-phase electric power supply, when in use.

14. Ohmic heating apparatus as claimed in Claims 2 to 13, wherein said inlet and outlet ports are positioned at opposite ends of said vessel on said axis, said ports being substantially smaller in area than the cross-sectional area of said vessel.

15. Ohmic heating apparatus as claimed in any of Claims 2 to 14 including an electrically conductive guard ring positioned to lie around the periphery of each of said ports, and means to connect each said guard ring to earth in use.

16. Ohmic heating apparatus as claimed in Claim 15 further including a second electrically conductive guard ring positioned to lie around the periphery of each of said ports at a position nearer to said electrode elements than the first guard ring, and means to connect each said second guard ring to the neutral of the electric power supply.

17. Ohmic heating apparatus for heating an electrically conductive fluid, comprising a vessel having inlet and outlet ports between which said fluid flows, when in use, along a longitudinal axis; at least two elongate electrode members arranged to be spaced about said axis and extend longitudinally within said vessel; each said elongate electrode member being formed of at least two electrode elements, each electrode element being electrically insulatable from at least adjacent electrode elements; and supply means to supply electric power to said electrode elements such that the electric potential at any time on said axis is one of a) substantially zero relative to earth, and b) the neutral potential of the electric power supply; and current detection means to detect the current flowing to said one or more electrode elements; said supply means including switch means to switch the supply of electric power to one or more sets of electrode elements in dependence upon the current detected by said current detection means; a set of electrode elements comprising at least one electrode element of each elongate electrode member, each said at least one electrode segment lying at a similar longitudinal position.

18. A method of ohmically heating an electrically conductive fluid comprising the steps of immersing electrode means in the fluid to be heated and supplying

electric power to selected electrode elements of a plurality of electrically separate electrode elements to adjust the effective electrode surface area.

19. . A method as claimed in Claim 18 comprising the steps of passing said fluid to be heated along a flow axis through a vessel and supplying electric power to said electrode elements which are spaced about said axis, such that the electric potential at any time on said axis is one of a) substantially zero relative to earth, and b) the neutral potential of the electric power supply.

20. A method as claimed in Claim 18 or Claim 19 including the step of detecting the current flowing in said fluid, and supplying electric power to selected electrode elements to increase the effective electrode surface area in response to a decrease in detected current, and to decrease the effective surface area in response to an increase in detected current.

21. A method as claimed in Claim 20, comprising the steps of supplying electric power to one or more sets of electrode elements in dependence upon the detected current; where a set of electrode elements comprises a plurality of electrode elements having the same longitudinal position.

22. A method as claimed in Claim 21 including the steps of supplying electric power to more sets of electrode elements when the detected current decreases, and supplying electric power to less sets of electrode elements when the detected current increases.

23. A method as claimed in Claim 21, wherein said electrode elements are elongate and extend in the direction of flow of said fluid, electrode elements of a first set of electrode elements having a length of about twice the length of electrode elements of a second set of electrode elements, said method comprising the steps of supplying electric power to both said first and second set of electrode elements, said second set of electrode elements, or said first set of electrode elements in response to a predetermined detected current, a two-fold increase or a three-fold increase in the detected current respectively.

24. A method as claimed in any of Claims 21 to 23 including the step of disconnecting the electric power supply if the detected current exceeds a predetermined threshold, and reconnecting said electric power supply after a predetermined time.

25. A method as claimed in any of Claims 18 to 24, wherein each electrode element of a set of electrode elements is energised using a single phase of a three-phase electric power supply.

26. Ohmic heating apparatus substantially as hereinbefore described with reference to the drawings.

27. A method of ohmically heating a fluid substantially as hereinbefore described with reference to the drawings.



**Patents Act 1977**  
**Examiner's report to the Comptroller under**  
**Section 17 (The Search Report)**

- 20 -

Application number

GB 9214731.3

**Relevant Technical fields**

(i) UK CI (Edition L ) H5H (HNN)

(ii) Int CI (Edition 5 ) H05B 03/60, 03/03, 03/02;  
F24H 01/10, 01/20

**Search Examiner**

J COCKITT

**Databases (see over)**

(i) UK Patent Office

(ii)

**Date of Search**

23 JULY 1993

Documents considered relevant following a search in respect of claims

1-27

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
X	GB 2229900 A (BECKSWIFT) see whole document for example page 37 lines 24-25	1, 17, 18 at least
X	GB 1095385 A (TOLARAM) see whole document	1, 17, 18 at least
X	GB 0725568 A (RAINBOWS) see whole document	1, 17, 18 at least

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Category	Identity of document and relevant passages - 21 -	Relevant to claim(s)

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